International Journal of Research in Applied, Natural and Social Sciences (IJRANSS)
ISSN 2321-8851
Vol. 1, Issue 1, June 2013, 9-12

ELECTRICAL MEASUREMENTS OF POLYANILINE AND CdS HETEROJUNCTION

NEMPAL SINGH[1], JITENDRA SINGH[2], SACHIN KUMAR[3], MANOJ KUMAR[4], ANSUL GAUR[5] & KAPIL SIROHI[6]

[1,3,4]Department of Applied Science, Indraprastha Institute of Technology, Amroha, Uttar Pradesh, India

[2]Department of Physics, K.G.K. College, Moradabad, Uttar Pradesh, India

[5]Department of Physics, Forte Institution of Technology, Meerut, Uttar Pradesh, India

[6]Department of Basic Education, Uttar Pradesh, India

ABSTRACT

In the present paper the thin film of CdS and Polyaniline has been developed by vacuum evaporation technique. The prepared thin films then deposited onto glass as well as metallic substrates. The glass substrate was cleaned in aquaregia, washed in distilled water and isopropyl alcohol (IPA). These prepared samples were then subjected for the electrical measurements by employing Keithley electrometer. In PANI/ CdS junction the conduction of charge across the junction is typically a mixture of electron from n-CdS side a polaron and bipolaron from p-Pani side. The n-CdS and p-Pani heterojunction also holds the promises of being studied and converted in to an active device. The low value of fill factor and conversion efficiency can be attributed to the polycrystallinity of the CdS thin film and vacuum deposited Pani thin film, as they do not make an extremely sharp perfect heterojunction. Also the substrate has a strong influence on the surface morphology of the films.

KEYWORDS: Vacuum Evaporation, Heterojunction, CdS, PANI

INTRODUCTION

The early development of semiconductors was centered on silicon, which gradually shifted to compounds semiconductors and much recently to an unexpected, entirely new class of material - the polymers. On the other hand the polymers like plastics were rigidly regarded as insulators until Heeger, Mac Diarmid and Shirakawa discovered that these polymers can be made conductive, equivalent to metals [1]. The conductivity of polymers depends upon the doping with chains. This discovery fetched these scientists the Nobel Prize in Chemistry for 2000. The conducting polymers have numerous advantages over metals, being light weight, flexible, relatively low cost and its possibility is much easier and simple. These can be processed at low temperatures than metals [2].

The semiconducting properties of polymers have triggered new enthusiasm in semiconductor physics, who have find application for optical & thermal sensors, chemical and gas sensors, solar cells, light emitting devices, thin flexible plastic display, conducting adhesive, transparent conducting and flexible conducting links, anti-static coating, electromagnetic shielding, molecular electronics, rechargeable batteries, conversion resistant coating etc [3-8].

Within a decade of time many polymers and their derivatives have emerged such as polythiophenes, phenylene-vinylene, polyfluorene etc. and are studied for their semiconducting properties [9]. The polyaniline has become the polymer of choice. It is very stable processed and environment friendly [10-11]. It's electrical properties can be customized easily. Recent research indicates towards its possible use in sensors, LED and other heterojunction devices [12].

The Polymeric thin films technology have already advanced to practical application in solar cells, detectors, sensors, optical memory devices, interference filters, xeroradiography, reflection and anti reflection coating etc.

The heterojunction of n & p type semiconductor is the criteria for photovoltaic, optoelectronic applications and sensors applications.

EXPERIMENTAL DETAILS

Sample Preparation of CdS and PANI

The film of CdS was prepared by vacuum evaporation technique, on to highly cleaned glass as well as metallic substrate held at room temperature in a vacuum of order of 10^{-5} torr. CdS powder (99.99% purity) was evaporated at about 200°C from a deep narrow mounted molybdenum boat. The glass substrate was cleaned in aquaregia washed in distilled water and isopropyl alcohol (IPA). The substrate was kept in a closed box with accuracy to avoid the dust particle on surface.

Thin film of Polyaniline have been prepared by vacuum evaporation technique, Polyaniline is usually prepared by redox polymerization of aniline using ammonium perdisulphate, $(NH4)_2$ S_2O_2 as an oxidant. Distilled aniline (0.02 M) is dissolved in 300 ml of pre-cooled HC1 (l.0M) solution, maintained at 0-50°C.

A calculated amount of ammonium perdisulphate, (0.05M) dissolved in 200 ml of HCl (1M), pre-coated to 0-50° C, is added to the above solution. The dark green precipitate (ppt) resulting from this reaction is washed with HC1 (l.OM) uptil the green colour disappears.

This ppt is further extracted with terta-hydrofuran and NMP (N-Methyl Pyrolidinone) solution by soxhelf extraction and dried to yield the emeraldine salt. Emeraldine base can be obtained by heating the emeraldine salt with ammonia solution. Simultaneously, separate salt solution is prepared by dissolving the MX (M=Metal and X=Halide) in distilled water.

The solution is then slowly added to the precooled polymer solution with constant stirring. The composite is then dried in an oven at high temperature, to get the conducting polymer in the powder form. This powder is vacuum evaporated on to highly cleaned glass substrate as well as metallic substrate.

Electrical Characterization

Characteristics

Schottky devised a model for metal-semiconductor contacts that is known as the schottky barrier (or schottky effect). There are a variety of applications using metal semiconductor contacts including diode, transistor, FET etc. When a metal is brought into intimate contact with a semiconductor, the conduction and valence bands of the semiconductors are brought into a definite energy relationship with the Fermi level in the metal.

The current voltage measurements of semiconducting thin films with metal contacts reflect the diode characteristics. The I-V measurements are seen to closely follow the diode equation of Schottky barrier diodes. The current voltage characteristics of CdS thin film on glass substrate is shown in figure 1.

The current voltage characteristics of such type of sample in which the polymeric thin film of Polyaniline is evaporated on to the same sample as discussed above indicate very interesting different type of conduction mechanism as shown in figure 2. Before illumination and after illumination junction characteristics illustrated in figure 3, indicate that these structures are a prerequisite for fabrication of microelectronic and optoelectronic devices.

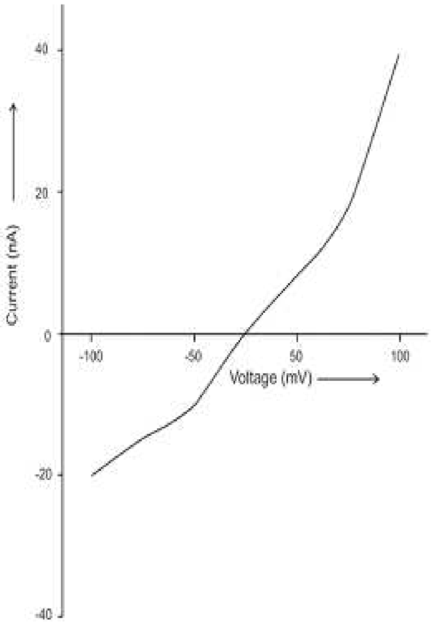

Figure 1: I-V Characteristics of / Glass Substrate

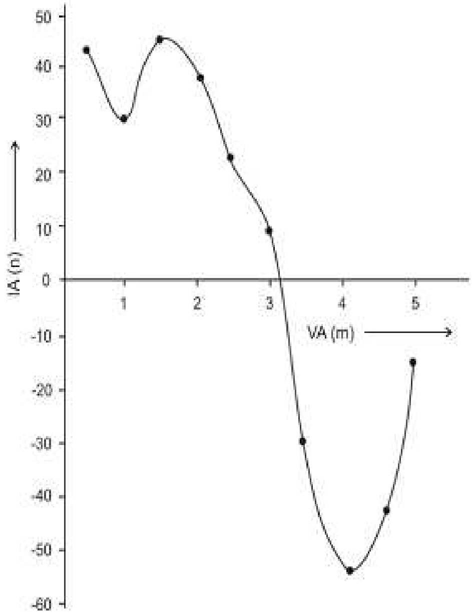

Figure 2: I-V Char of PANI/CdS/Glass Substrate

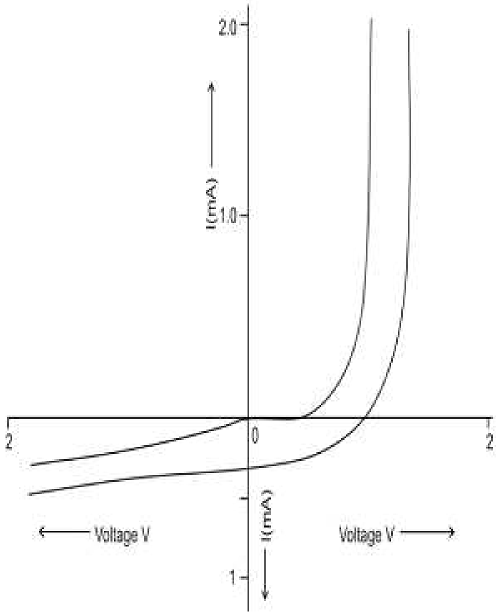

Figure 3: I-V Char of Pani/CdS Junction

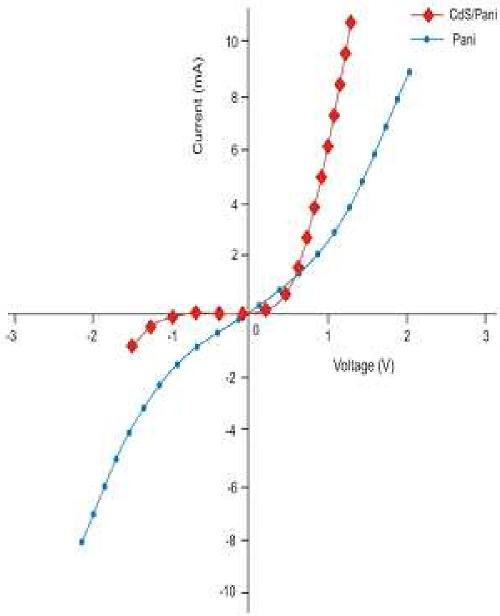

Figure 4: I-V Char of Pani & CdS/Pani Hetero Junction

Polyaniline Pallet/CdS Thin Film Junction

In addition to the work done on Polyaniline/CdS thin films as discussed above we have also tried junction of CdS thin film and Polyaniline pallet. The I-V characteristics of Pani and CdS/Pani junction is shown in figure 4.

Conducting polyaniline (PANI) has been synthesized using Sol-Gel technique with chemical oxidation process. Thermal and environmental stability of the synthesized sample of PANI is investigated by measuring the thermal transport properties of the samples at different temperatures and time using Transient Plane source (TPS) technique. The results indicate that the PANI shows excellent thermal and environmental stability. Chemically prepared Cadmium Sulphide has been printed on a pallet of conducting Polyaniline (of 1.2 cm diameter and 2 mm thickness). This pallet of CdS coated conducting Polyaniline has been sintered at 150° for six hours for ensuring better adhesion. The I-V characteristics of CdS, conducting Polyaniline and CdS coated conducting Polyaniline have been recorded at room temperature using Keithley

electrometer. The results indicated that I-V of CdS is ohmic whereas that of conducting Polyaniline is observed to be non-ohmic. PANI is a p-type material and CdS is an n-type material. The junction formed in CdS coated PANI is a p-n junction. I-V characteristic of this junction shows diode characteristic. This confirms that a good diode can be fabricated by using such a simple technique.

RESULTS DISCUSSIONS

In PANI/ CdS junction the conduction of charge across the junction is typically a mixture of electron from n-CdS side a polaron and bipolaron from p-Pani side. In addition to observing a thermionic emission, Schottky I-V characteristics are also observed, a pool frankly and trap assisted field emission, a non-linear behavior. The junction characteristics of Pani/CdS thin film are complex of many conduction mechanisms and cannot be explained by simple theory.

The n-CdS and p-Pani heterojunction also holds the promises of being studied and converted in to an active device. The low value of fill factor and conversion efficiency can be attributed to the polycrystallinity of the CdS thin film and vacuum deposited Pani thin film, as they do not make an extremely sharp perfect heterojunction. Also the substrate has a strong influence on the surface morphology of the films.

REFERENCES

1. Chiang, C.K; Fincher, C.R; Park, Y.W.; Heeger, A.J.; Shirakawa, H.; Louis, E.J.; Gau, S.C.; Mac Diarrmid, A.G. phys, Rev. lett 1977, 39, 1098.
2. Grandstrom, M. et al Nature 1998, 395, 257.
3. Liu,G. ; Freund, M.S., Macromolecule 1997, 30, 5660.
4. Barllett; P.N.; Asiter, Y. Chem. Commun. 2010, 105, 391.
5. Jasty, S.; Epstein, A.J. Polym. Material. Sci. Eng. 1995, 72, 56.
6. Thompson, B.C. et al Chem. Mater. 2000, 12, 1563.
7. Burroughes, J.H. et al. Nature, 1990, 347, 152.
8. Conducting Polymers: Ease of processing spear heads commercial success, Savage, Peter, Ed.; Technical Insight; Inc./John Viley & Sons, NJ, 1998.
9. Electronic Properties of Conjugated Polymers; Kusmany, H.; Mebring, M., Eds.; Springer Verlag; Berlin, 1998; Vol. 76.
10. MacDiarmid, A.G.; Epstein, A.J. Farady Discuss Cham. Soc. 1989, 88, 317.
11. Cao, Y. et al Synth Mater 1995, 69, 187.
12. Tseng, Y.C.; Tzolov, M.; Sargent, E.H., Cyr, P.W.; Hams, M.A., Appl. Phys. Lett. 2002, 81, 3446.